

**SAP White Paper  
mySAP SCM**



# **MANUFACTURING STRATEGY: AN ADAPTIVE PERSPECTIVE**

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## EXECUTIVE SUMMARY

To be successful in today's increasingly time-sensitive and competitive markets, businesses need manufacturing processes that are fast, flexible, and adapt quickly to change. Achieving this objective requires integrated solutions that connect supply chains to factory processes, production equipment, and factory systems in a seamless, customer-centric network. SAP, with its broad industry experience, is the leading global developer of such solutions.

## FLEXIBLE, FAST, ADAPTIVE PROCESSES – THE KEY TO COMPETITIVE MANUFACTURING

### INTRODUCTION TO ADAPTIVE MANUFACTURING

Over the past decade, competitive businesses have worked hard to reduce the amount of “capacity fat” and “inventory fat” in their supply chains. These initiatives have led to dramatic improvements in operational efficiency and the emergence of today's increasingly lean and responsive supply chain. They are an important step toward competitiveness. But to achieve full competitive status, a company must integrate its supply chain into its manufacturing operations.

Supply chains are, metaphorically, the arteries that carry and distribute blood to the enterprise; the factory is the heart that pumps the blood. Good, free-flowing distribution arteries are vital to business efficiency – but only when they are supported by a manufacturing process that responds as needed to changing conditions. And manufacturing – the heart of the supply chain – has not yet been effectively incorporated into the streamlining process. It remains, for the most part, disconnected from the supply chain, a condition that becomes more evident as global manufacturing becomes more fragmented.

### Integration: Today's Challenge

As supply chains continue to become leaner and the level of fat (inventory, capacity, labor) continues to drain, companies whose manufacturing capabilities cannot respond quickly to variable demands become increasingly vulnerable. These companies are now searching for ways to integrate all their manufacturing activities and connect them with the supply chain. But the majority of point solutions available to help them address this problem are inadequate to the task because they work only in very localized environments and fail to have wide industry application. That's why, to date, most supply chain projects have focused on generating savings through inventory optimization (by reducing raw material, work-in-process, and finished goods). But far greater savings are possible by linking manufacturing to the supply chain.

Consider: In typical manufacturing companies, 40% to 70% of the total assets in the supply chain are fixed (plant and machinery). Companies that leverage these fixed assets productively are capable of generating higher-than-normal returns. Examples abound. Some of the world’s foremost automobile companies (known for their lean production philosophy) and some of the world’s most efficient computer manufacturers (known for their mass customization and flexible manufacturing capabilities) have been leveraging their manufacturing competence to generate financial benefits that far outstrip those generated by their peers.

**The Move Toward Adaptive Manufacturing**

Adaptive manufacturing enables companies to produce goods efficiently and manage variability proactively. Efficient production requires a system with efficient planning and execution capabilities. Proactive management requires a system that can rapidly sense and respond to any exceptions that impact manufacturing while continuing to incorporate learning into manufacturing processes.

To create a manufacturing process that is continuously adaptive, companies must:

- Intelligently leverage applications and technology to connect “plan-execute-sense-respond-learn” operations
- Seamlessly link factory processes, production equipment, and factory systems to supply chain operations

Adaptive manufacturing must be managed as an end-to-end, closed-loop process with tight linkages between the manufacturing applications, other adjacent enterprise applications, and – most importantly – the technology that enables these applications across the distributed manufacturing base. Such integrated networks enable the process visibility and collaboration capabilities that are key to building an adaptive manufacturing enterprise. SAP, the largest provider of world-class, enterprise-level manufacturing software, develops and enhances people-

centric manufacturing applications that are seamlessly integrated into supply chain applications, providing customers with the best and most profitable business solutions available.

**MANUFACTURING VALUE PROPOSITION**

Companies that lead their peer groups will always demonstrate faster asset velocities, commonly referred to as return on assets (ROA). ROA is arguably the most significant key performance indicator for measuring manufacturing effectiveness.

Mathematically, ROA is a direct function of profit margin and asset turns (asset velocity). Manufacturing impacts profit margins by helping improve top-line sales as well as reducing bottom-line costs. It impacts sales revenue via enhanced throughput on the shop floor, improved fill rates (service levels), and faster time-to-market (because of strong integration with engineering, design, and supply chain operations). And it impacts costs through asset turns. There are two types of asset turns, fixed and variable. Fixed asset turns commonly refer to the machinery and equipment on the shop floor; variable asset turns refer to the inventory impacted by manufacturing. This inventory can be raw material (RM), finished goods (FG), or work-in-process (WIP). Figure 1 shows the components that constitute the ROA equation and the key operational metrics directly affected by manufacturing operations.

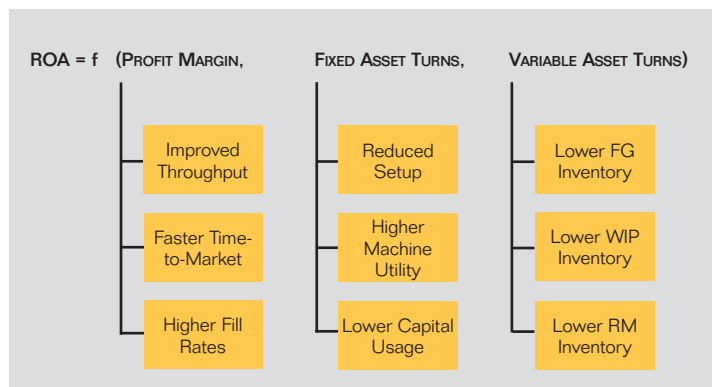


Figure 1: Impact of Manufacturing Metrics on ROA

Of all the assets that exist within supply chain networks – including different types of inventory and capital assets such as plant, machinery, warehouses, and transportation equipment – 40% to 70% is directly related to manufacturing operations. Clearly any efficiencies achievable in these operations can have significant impact on a company’s profitability. The potential for savings is a strong incentive for building an adaptive manufacturing capability that can efficiently manage economies of both scope and scale by leveraging the company’s assets intelligently and producing to near real-time demand.

### MANUFACTURING CHALLENGES

Despite significant improvements in manufacturing efficiencies over the years, producing to near real-time demand is easier said than done – especially in a business environment where variability is continually increasing. Some of the drivers responsible for this increase in variability – and thus challenging manufacturing to achieve adaptive capabilities – are:

- **Fragmented manufacturing facilities.** Globally distributed manufacturing locations are increasing exponentially, demanding new manufacturing visibility and collaboration.
- **Mass customization.** The rapidly increasing cross-industry demand for product variety presents challenges in areas such as manufacturing capacity and resource planning.
- **Shrinking life cycles.** Product life cycles are rapidly shortening, and pose challenges in areas such as manufacturing cycle time, productivity, and inventory management.
- **Response velocity.** Customer empowerment is driving managers to target new levels of flexibility, leading to higher manufacturing capacity costs and labor deployment challenges.
- **Zero defect quality.** Product quality requirements are becoming increasingly stringent, causing manufacturers to focus on “Zero Defect” production capabilities.

The severity of these challenges is intensified because of specific technology challenges that impact visibility and collaboration, and hinder responsiveness. These technology challenges include:

- **Proprietary practices.** Arrays of proprietary interfaces, platforms, and communication protocols at shop-floor levels make it difficult to extract information to central databases.
- **Finite modeling capabilities.** Most aggregate and finite planning systems are disparate in nature and cannot model quickly and efficiently enough at granular levels to create accurate schedules. Integration of aggregate planning and finite planning data remains a challenge.
- **Data management.** The explosive growth of data collection and analysis requirements, though recognized as a key issue, is hindered by lack of integration and analytical capabilities.
- **Shop-floor visibility.** Current systems allow little bidirectional propagation. The detailed line and inventory scheduling done at floor levels is not visible to planning and execution systems. Shop floors rarely have visibility into last-minute changes in customer orders. This lack of visibility has a spiraling effect on future production schedules and impacts how resources are used.
- **Traceability.** The inability to systematically trace, rework, and see WIP hinders resource planning efforts and impacts capacity.

These challenges indicate that purely traditional manufacturing practices, which were based on the push and made-to-stock philosophy with little visibility to true demand, will not succeed in the current business environment. Manufacturers will have to transition to operating in a continuously adaptive mode.

Table 1 differentiates the characteristics that can enable companies to adapt to the current dynamic environment. Successful companies will leverage adaptive manufacturing capabilities to tightly integrate dispersed manufacturing facilities into supply chain operations, and enhanced visibility and collaboration will ultimately enable adaptive manufacturing.

Characteristic	Traditional Manufacturing	Adaptive Manufacturing
Philosophy	Push & Stocked	Flexible & Responsive
Order Execution	Batch Executions	Dynamic Reallocations
Capacity Management	Batch & Centralized	Dynamic & Distributed
Exception Management	Centralized & Manual	Automated & Distributed
Planning	Periodic Scheduling	Real-Time Scheduling
Shop-Floor Visibility	Blurred & Batch	Transparent & Real Time
Material Release Schedules	Push	Pull
Analytics	Historical	Real Time
Connectivity	Disconnected/Multiple Databases	Connected MFG-ERP-SCM-PLM
Collaboration	Sequential and Slow	Networked and Real Time
Standards	Proprietary	Open
Driver	Material & Capacity Utilization	Profitability Optimization

Table 1: Adaptive Manufacturing Characteristics

## MANUFACTURING ROAD MAP: FROM PUSH TO ADAPTIVE

Compared to the supply chain revolution of the early 1990s, today's manufacturing revolution is relatively mature and has seen several phases of transition. Table 2 describes the evolution of the various manufacturing stages, starting from the push manufacturing of the 1970s to the adaptive manufacturing that is fast becoming a standard practice. Table 3 goes on to outline the key characteristics of each of these manufacturing stages.

*It is important to understand that the newer manufacturing practices do not replace the older ones but instead continue to blend the best of the current and past manufacturing practices to meet current business needs.*

Thus, although various manufacturing philosophies currently exist – push, lean, flexible – none are applied in a pure, holistic fashion. Most companies run a hybrid system.

### Push Manufacturing

The 1970s was the era of push manufacturing. At that time it was still a sellers' market for the most part, and companies were focused primarily on building capacity and maximizing production throughput. Product variety was nowhere near the challenge it is today, and almost all that was produced was built to forecast.

This was the era that also saw the real emergence and popularity of material requirements planning (MRP), which became recognized as a key tool for enhancing productivity. Not only did MRP enable companies to better manage inventory, it led – in the late 1970s – to the emergence of manufacturing resources planning (MRP II) and enabled companies to do systematic capacity requirements planning (CRP). For the first time, a feedback loop was established from the CRP module to alert when there was not enough capacity available to produce to plan.

Period	1970s	1980s	1990s	2000 & Beyond
Manufacturing Practice	Push Manufacturing	Lean Manufacturing	Flexible Manufacturing	Adaptive Manufacturing
Key Market Differentiator	Cost	Quality	Availability	Lead Time
Performance Indicators	Production Throughput	Cost Management	Segment Market Share	Customer Satisfaction

Table 2: Evolution of Manufacturing Practices

### Lean Manufacturing

The push manufacturing decade was followed by the lean manufacturing era. Popularized by the Japanese as just-in-time (JIT) or pull manufacturing, the principle focus of the lean manufacturing philosophy was to minimize all forms of waste and produce quality products. Rework was considered the worst waste of all, and one of the primary metrics of lean manufacturing was “first pass” quality.

Not surprisingly, the greatest impact of lean manufacturing was in the reduction of waste. The philosophy worked well in an environment of low product variability and relatively stable customer demand. By focusing on narrow product mixes with relatively predictable demand, many of the lean factories of the 1980s outperformed conventional plants that were still following a purely push production philosophy that focused primarily on building capacity. The automotive industry profited most from lean manufacturing, and the best practices from the automotive industry have since penetrated several other industry sectors.

### Flexible Manufacturing

The late 1980s and early 1990s witnessed the emergence of flexible manufacturing practices. This postindustrial phenomenon was a response to more volatile markets, higher product proliferation, shorter life cycles, quicker response capabilities, and more

sophisticated buyers. All of these factors increased business complexity significantly and led to the breakdown of the lean principles that focused on stable demand and relatively low product variation.

In this new environment, responsiveness and product availability were key to maintaining sales and market share. Flexibility became the new strategic imperative. Flexible manufacturing exploited the gain from product proliferation and mass customization to reach economies of scope. Flexible manufacturing practices also popularized the concepts of general-purpose machines and equipment, cross-trained workers, information technology, well-developed vendors, and a highly trained indirect staff.

But flexible manufacturing was not without its flaws, chief among them being the cost of flexibility. Companies came to realize that although some excess flexible capacity allowed better management of variability, outsourced manufacturing was often a more viable means to the same end. Thus began the era of outsourcing. Outsourcing had a dramatic impact on a company’s cost structure. Large chunks of fixed costs simply disappeared. On the downside, with outsourcing came loss of control. As manufacturing moved outside the four walls of the company, visibility became a major concern. The focus shifted to collaborative capabilities, and technology began having a major impact on visibility and collaboration.

Manufacturing Practice	Characteristics	Philosophy
Push Manufacturing	Mass production	Maximize capacity utilization to lower costs
	Focused assembly lines	Focus on availability and economies of scale
Manufacturing Practice	Characteristics	Philosophy
Pull (Lean) Manufacturing	Produce only what is to be sold	Significant focus on product and process quality
	Flow philosophy	Production smoothing by lot size management
	Limited product variety	Enterprise metrics – across major functions
Manufacturing Practice	Characteristics	Philosophy
Flexible Manufacturing	Significant product variety	Ensure product availability at any cost
	Redundancy availability	Accept variability – focus on economies of scope
	Focus on TOC principles	Enterprise metrics – across major functions
Manufacturing Practice	Characteristics	Philosophy
Adaptive Manufacturing	System integration for visibility	Compete on service and minimize lead times
	Enhance network collaboration	Cost and velocity of flexibility
	Manage by analytics	Collaborative metrics across business partners

Table 3: Manufacturing Processes

The late 1990s and the early part of this century have seen the dramatic impact of technology on productivity. The efficiency benefits of push manufacturing, the quality benefits of lean manufacturing, and the responsiveness benefits of flexible manufacturing have all become plain market qualifiers. Thanks to the Internet and information ubiquity, the customer has finally been crowned king, and companies that adapt quickly and efficiently to the king's variable demands are destined for success.

Adaptive manufacturing is the key characteristic driving this success. Adaptability has two primary characteristics, flexibility and velocity. Flexibility enables a manufacturing unit to scale efficiently while velocity determines its ability to switch operational modes rapidly and to transition between modes such as high-volume/low-mix to high-volume/high-mix product loadings. Adaptive manufacturing enterprises are expected to achieve required flexibility and velocity by linking technology to factory processes, production equipment, and factory systems. This integrated technology will allow them the profitable manufacture of products for increasingly time-sensitive and competitive markets.

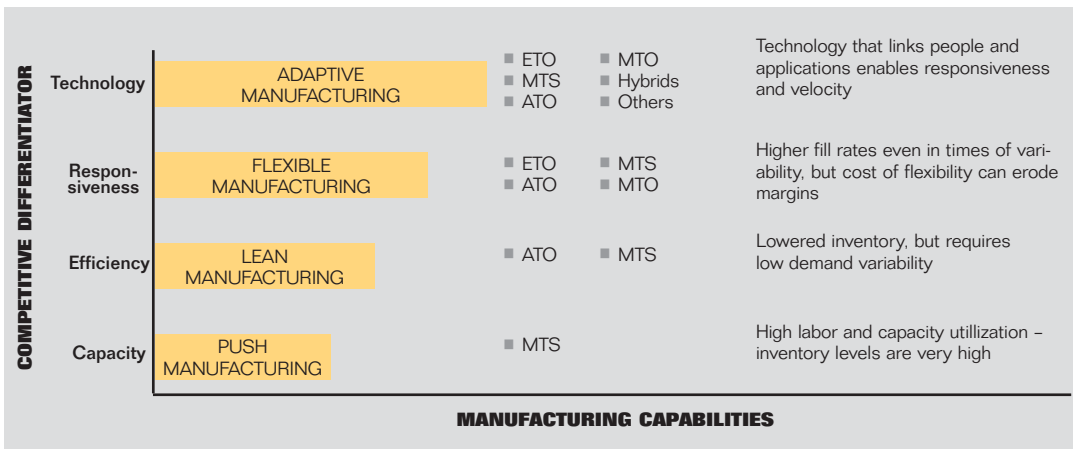


Figure 2: Manufacturing Processes

### MANUFACTURING METHODS

To understand the impact of manufacturing on supply chains, it's necessary first to understand how manufacturing evolved and then to map the different manufacturing philosophies to manufacturing methods. The four manufacturing philosophies just discussed can be mapped to four key manufacturing methods: make-to-stock (MTS), assemble-to-order (ATO), make-to-order (MTO), and engineer-to-order (ETO). All of these methods have value, depending on the needs of the business environment and the need for supply chain networks to keep up with the variability introduced as a result of proliferation of products, customers, and channels. Companies almost always have to adopt a hybrid mix of these manufacturing processes. Figure 2 shows how the various manufacturing philosophies can be mapped to different manufacturing processes.

The **push manufacturing** philosophy, which focuses on maximizing capacity, is most suited to an environment with predictable demand. It meets the needs of a traditional supply chain operation (one based on projected sales and operation plans) and a master production schedule. Thus it works best in an

environment where production complexity as well as demand variability are relatively low. In an MTS manufacturing strategy, the supply side process is completely forecast-based and stretches from the acquisition of raw materials to the deployment of finished goods inventories into the channel. The delivery process involves taking an order and delivering it to the customer.

The **lean manufacturing** philosophy also works best in an environment with stable demand, but it has a far greater pull focus. Typical lean manufacturing environments are a mix of push and pull, with the pull point being further upstream than it is in push manufacturing. Therefore the ATO process is a good fit here – in addition to the MTS process. In lean manufacturing, the supply side of the process is focused on staging of raw materials or build-to-stock (BTS) semi-finished assemblies throughout the supply network, while the delivery side includes taking an order, doing final assembly, and delivering the product to the customer.

For businesses that have larger degrees of variability, **flexible manufacturing** is a potential solution. The flexible manufacturing principle maps well to the BTO process. This process in principle is similar to the ATO process except for the fact that the staging of the raw materials or BTS semi-finished assemblies is done relatively further upstream, and some excess capacity and inventory is considered a good tradeoff for building a responsive manufacturing facility.

As levels of variability continue to increase, and characteristics such as cost, quality, and availability become market qualifiers, velocity of response is becoming the key differentiator within an increasingly mass-customized environment. **Adaptive manufacturing** leverages technology to build hybrid-manufacturing capability that benefits from the best practices of all manufacturing processes including MTS, ATO, MTO, and ETO. In an adaptive process, both the supply side and the customer-facing fulfillment side are based on collaboration technology that maximizes visibility across the supply chain.

### INDUSTRY APPLICABILITY

It is also important to recognize the general mapping of manufacturing processes to industries. This mapping is by no means perfect. However, based on the relative production complexity and demand variability evidenced in the different sectors, it is possible to attach different industries to the manufacturing methods generally practiced in them. Process manufacturing, for example, is a good fit for the MTS manufacturing method. In the MTS process, the supply chain manages almost the complete inventory replenishment forecasts that end upstream with the raw material supplier. Figure 3 shows a sample list of industries that fit well in this category. They include chemicals, pharmaceuticals, and oil and gas, as well as some stable discrete manufacturing sectors.

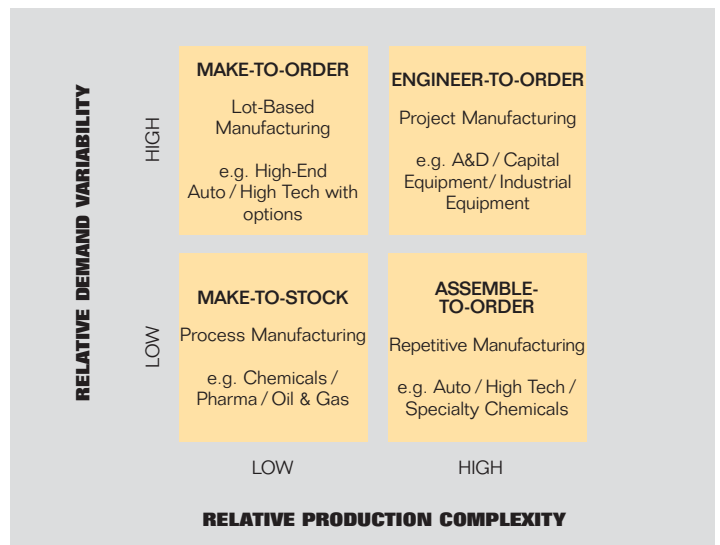


Figure 3: Mapping Industries to Manufacturing Practices

ATO and MTO have similar industry applications, mostly in repetitive manufacturing and lot-based manufacturing environments. The major difference is in the degree of variability, which in turn determines the volume of WIP inventory buffer used to separate the two categories. In the ATO environment, the WIP inventory buffer being managed is relatively greater and further downstream (closer to the finished product) than the buffer held in the MTO manufacturing environment. Thus ATO is more applicable in a repetitive manufacturing environment with relatively lower upstream variability, whereas MTO is more applicable to a lot-based manufacturing environment.

Such hybrid manufacturing environments are becoming increasingly common within specific industries and represent a combination of push and pull manufacturing strategies. The interface between the push and pull occurs at the point in the supply chain where the total remaining downstream time (customer delivery time) to complete and ship the finished goods is

just longer than the delivery time committed to the customer. Downstream inventory, therefore, is not replenished until it stands depleted at the interface between the push and pull points. Based on the target fill-rate policies and the variability factor, the interface point (also called point of postponement) between the pull and push supply can move upstream or downstream. The industries that benefit most from hybrid manufacturing are automotive and high tech.

In the ETO manufacturing process, the supply chain is not activated unless there is a firm customer order. Some examples of industries using this process include aerospace and defense, capital equipment, and specialized machinery, where design, engineering, manufacturing, and purchasing must work together closely. It is in ETO manufacturing that collaboration technologies have had the most impact.

### MAPPING MANUFACTURING METHODS TO SUPPLY CHAIN STRATEGY

Because of the diversity in industry practices as well as the variety of product lines within similar industries, most companies will always need a hybrid blend of manufacturing practices. As mass customization becomes increasingly essential, it becomes even more important to understand the part of the supply chain that works best under a push-driven mechanism and the part that can be managed as a pull system.

Figure 4 maps manufacturing processes to push and pull supply chains to determine the decoupling point that splits the supply chain into two distinguishable parts, one that is oriented toward firm customer orders (the pull part) and one that is based on planning (the push part). This decoupling point often depends on the longest lead time the customer is prepared to tolerate and the point at which the variability in product demand increases

significantly. The push part of the supply chain is primarily forecast driven whereas the pull part is demand driven. The decoupling point or interface between pull and push is frequently referred to as the point of postponement (POP).

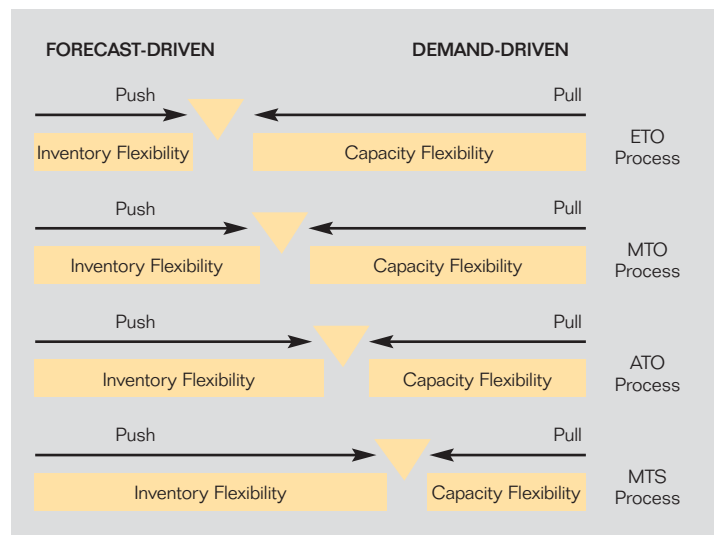


Figure 4: Mapping Push and Pull Supply Chains to Manufacturing Practices

The POP is also determined based on the tradeoff between inventory flexibility and capacity flexibility. The greater the push influence on the supply chain, the higher the need for inventory flexibility; the greater the pull influence on the supply chain, the higher the need for capacity flexibility. Based on the different manufacturing processes (MTS, ATO, MTO, and ETO) the position of the POP varies. The POP, therefore, is a floating point separating the supplier-facing side and the customer-facing side of the supply chain.

The greater the velocity and visibility across the supply chain, the better the possibility of pushing the POP further back upstream in the supply chain. It is thus essential that a company defines its hybrid manufacturing strategies for different customers and product segments, then aligns its performance management scheme to each strategy. Once the strategies are identified, the objective of adaptive manufacturing is to continually modify the POP and successfully push the interface between supply management and customer fulfillment further back in the supply chain (upstream). This minimizes the need for inventory, forecast dependency, kitting, setups, and warehousing – and allows for efficient late-stage differentiation.

### **THE TECHNOLOGY IMPACT**

As economies of scale change to economies of scope, velocity of response is quickly becoming the primary factor driving customer satisfaction. Although process and applications both play key roles in the transition to an adaptive manufacturing enterprise, the companies that differentiate themselves most significantly from the competition will be those that successfully leverage technology to enhance visibility and collaboration capabilities across the supply chain network.

Two distinct forces are compelling companies to start thinking of technology as the key enabler of manufacturing:

- Manufacturing is becoming increasingly fragmented and is spreading globally across diverse locations. With very few plants building complete assemblies, new levels of information visibility are needed to enable synchronized production across the supply chain and manufacturing network.
- Competitive pressures are forcing the development of mass customization manufacturing capabilities that allow companies to fulfill customer demand profitably. This trend requires new levels of interconnectivity between systems to aid collaboration among partners involved in design, manufacturing, engineering, supply, and distribution.

These two forces significantly complicate the day-to-day challenges manufacturing companies have always been confronted with because of lack of visibility and collaboration – challenges such as the following:

- Engineering desires to identify all current work orders for a given product to determine the impact of an urgent engineering change order.
- A machine that is critical for meeting customer due dates goes down, and the current orders across the network need to be rescheduled.
- The optimum sequence for all open work orders needs to be scheduled based on the supply and the hours available.
- A sudden customer indication shows that the order size needs to be doubled – keeping the delivery date unchanged – or the entire order will be canceled.

### **Stand-Alone Systems No Longer Sufficient**

In the past, when manufacturing was centralized and most critical steps occurred under a single roof, traditional point applications such as manufacturing execution solutions (MES) were adequate in most instances to address day-to-day issues. Companies could implement MES in a plant and then one by one create interfaces to send information within the same plant to the different computer-aided design (CAD), computer-aided manufacturing (CAM), enterprise resource planning (ERP), supply chain management (SCM), product data management (PDM), and supplier relationship management (SRM) systems.

Many industries still use such stand-alone systems for managing shop-floor activities to improve productivity and quality. Some of the common shop-floor information and activities these systems support are resource allocation, dispatching production units, quality management, operation planning, detailed scheduling, labor management, product tracking, and keeping records of product genealogy.

But given the current fragmented state of manufacturing, stand-alone solutions have little value. Companies need a collaborative layer of applications that can provide a single point of contact among application modules across the network – applications that allow information to be sent back and forth to the enterprise with data aggregated from several different factories. In short, to be successful in today’s business environment, companies need solutions that can work across an international, multisite, multi-company, distributed environment. This includes scalable manufacturing solutions that can work both in a distributed environment and across different hardware platforms and operating systems.

### **Web Opens New Potential for Connectivity**

With the maturing of Web platforms and the establishment of the Internet as a communication channel, it is now possible and economically feasible to connect shop-floor operations. It is also possible to forget links between manufacturing applications and other enterprise applications (such as ERP, SCM, CRM, PDM, and SRM) within and across organizational boundaries. XML-based technology is providing the economical option required to manage the diversity of data, applications, and devices that business processes need today. Such technology can bring key benefits to manufacturers – benefits that include:

- Global visibility of shop-floor operations and the ability to act based on this information
- Establishment of collaborative workflows between partners
- Zero latency of information (data, content, intelligence)
- Systematic synchronization of information and business process flows
- Optimization of processes within and between partners
- Intra- and inter-enterprise communication and integration

### **VIEW OF THE SAP® SOLUTION**

SAP® manufacturing solutions have functionalities that extend deep into the shop floor. Figure 5 shows how SAP’s adaptive manufacturing philosophy lines up with its adaptive supply chain network to enable fast, flexible response in manufacturing operations.

Planning and execution comprise the feed-forward loop that manages production on the shop floor while sense and respond comprise the feedback loop that enables constant monitoring of manufacturing and efficient management of deviations. In adaptive manufacturing, learning is a continuous process; knowledge and lessons learned are continuously incorporated into the manufacturing process. SAP provides solutions that enable all these components – planning, execution, sensing, responding, and learning. Table 4 outlines how these components apply to manufacturing.

SAP currently offers the broadest range of solutions for the manufacturing industry – solutions that support various manufacturing methods. Some of the key methods SAP supports are:

- Make-to-Stock
- Make-to-Order
- Assemble-to-Order
- Configure-to-Order
- Lean Manufacturing
- Repetitive Manufacturing
- Manufacturing with Final Assembly
- Manufacturing without Final Assembly

To enable such a wide variety of manufacturing methods, SAP provides an unmatched set of capabilities that are being used by thousands of customers around the world. Figure 6 shows the shop-floor application capabilities enabled by SAP. These include engineering, planning, execution, materials management, batch management, and process control for all discrete and process industries. Details of these capabilities appear in Appendix A.

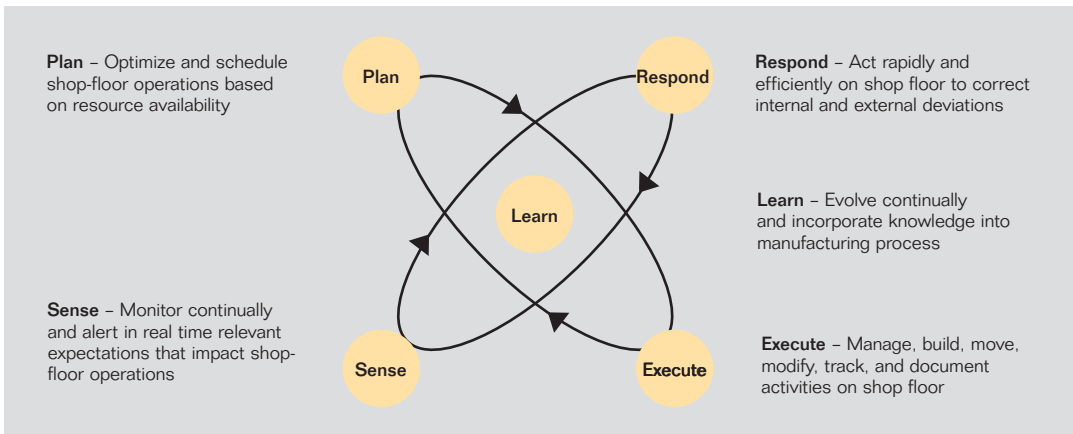


Figure 5: Dimensions of Adaptive Manufacturing

In addition to offering a broad set of shop-floor capabilities, SAP provides seamless connection into other key enterprise processes – SCM, SRM, CRM, PLM, and finance and accounting – as well as into standard OPC interfaces. And the company’s online data access (ODA) is a convenient way to link the manufacturing applications to automation and process control.

SAP draws upon its sheer breadth and depth of industry experience to build both generic and industry-specific workflows that enable manufacturing as well as the cross-functional processes attached to manufacturing. Some of these related processes include order management, product design, and fulfillment coordination. SAP’s proven and tested capabilities are used across different industries of different sizes, including:

- Aerospace and defense
- Automotive
- Chemicals
- Consumer products
- Engineering and construction

Area	Feature
Plan	Determine optimal manufacturing sequence, taking into consideration operating margins, material, labor, machine resource availability, shop-floor constraints, and delivery dates.
Execute	Manage production, track resource usage, track production batches, confirm production stages/status, obtain electronic approvals, document results, and log shop-floor activities.
Sense	Monitor and provide visibility about events that impact manufacturing, including inventory, cycle time, order and WIP status, and supplier deliveries. Identify exceptions to relevant personnel.
Respond	Act rapidly to allow relevant manager to modify decision to minimize impact of exceptions, including process delays, rejects, missing goods, breakdowns, change in order size, and supplier delays.
Learn	Enable decision making by suggesting relevant actions based on predefined business rules and continually provide measurement of key manufacturing metrics

Table 4: Characteristics of Adaptive Manufacturing

In addition to enhancing current manufacturing solutions (based on input received from its large user base), SAP continues to build additional manufacturing application capabilities that industries will need in the future. Some of these are shown in Table 5.

**Master data management** provides manufacturing companies with a common data platform from the design phase through the entire product life cycle. This will be shared across other functions, including purchasing, finance, and engineering, enabling faster time-to-market and time-to-volume, and significantly reducing errors that impair the design-engineering-manufacturing collaboration.

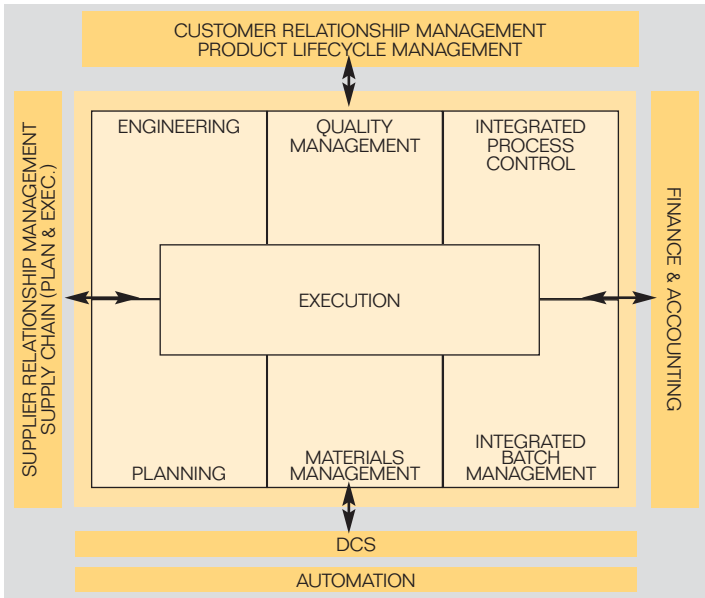


Figure 6: SAP Manufacturing Solution Capabilities

**Event-driven manufacturing** allows earlier and smarter visibility into exceptions. Conditional logic rules enable the dynamic alerting that minimizes the impact of exceptions.

A **manufacturing portal** is key to people-centric manufacturing, where every individual on the shop floor – planner, supervisor, quality manager, production manager – will have user-specific, easy-to-navigate screens that will increase efficiency and enhance worker productivity.

<b>Master Data Management</b>
Common master data model for manufacturing, planning, and execution Tight integration to PLM – engineering to service Tighter integration to financials
<b>Event-Driven Manufacturing</b>
Manufacturing processes controlled by events Flexibility to handle planned and unplanned events Flexible integration to automation
<b>Manufacturing Portal</b>
Role-based, task-driven UI in a manufacturing portal Improved visibility into allocation/balancing of tasks with workers Increased security across operations
<b>Common Technology Platform – SAP NetWeaver™</b>
Single technical platform across shop operations Open with interconnection to other vendor systems Connect shop floor to corporate operations and other business processes

Table 5: Additional Manufacturing Capabilities

Augmenting the above developments is **SAP NetWeaver™**, the SAP technology platform. As seen in Figure 7, SAP NetWeaver holds all the applications together and helps unify and align people, information, and business processes across technologies and organizations. It is comprehensive, best-in-class, integrated technology based on SAP’s longstanding experience in developing mission-critical business solutions.

SAP NetWeaver helps leverage a company’s existing IT investment and provides the foundation for future innovative, cross-enterprise processes. Based on open standards and Web-based architecture, it supports a heterogeneous IT landscape and is fully interoperable with .NET and J2EE environments. Figure 7 shows the SAP NetWeaver technology stack.

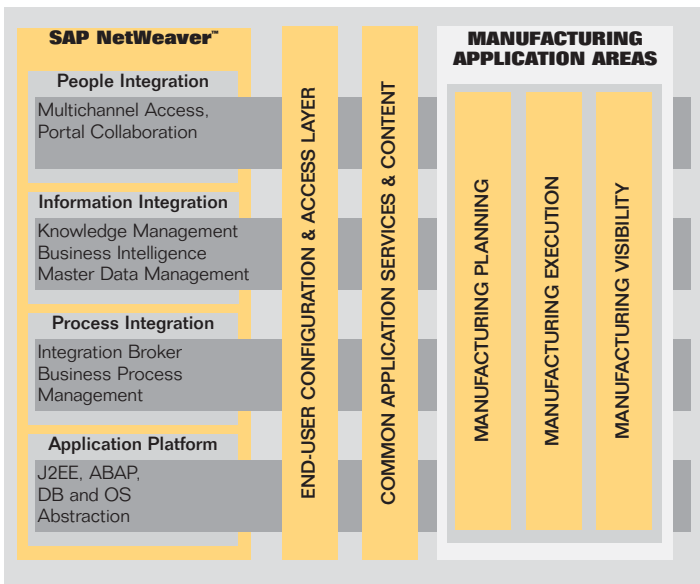


Figure 7: SAP NetWeaver

The SAP NetWeaver platform combines best-in-class components (such as an enterprise portal and business intelligence) into a business-ready platform. All components are built on the SAP Web Application Server, and common development, administration, and security environments are used across all components. Although SAP NetWeaver's Web Dynpro environment is used to develop and run the user interface for applications across the platform, the portal is the information delivery framework for all applications – SAP or non-SAP. The Integration Broker and Business Process Management provide process-centric integration for SAP and non-SAP systems within and beyond enterprise boundaries based on open standards such as XML, Java, and Web services standards.

SAP NetWeaver integrates both structured data (with best-in-class business intelligence capabilities), and unstructured data (with knowledge management capabilities). Business intelligence (BI) capabilities include a robust BI platform; a complete suite of BI tools (including reporting, analysis, and information delivery); data warehouse management and administration; and extract, transformation, and loading (ETL) capabilities. Knowledge management capabilities include user-centric services that provide a single access point to third-party repositories as well as to SAP's own content management systems. Knowledge management also delivers integrated search, taxonomy, classification, content management, and publishing capabilities, and supports customized workflow processes. It is the key to successfully linking manufacturing applications, both within and across organizations.

#### **ADAPTIVE MANUFACTURING: AN ACHIEVABLE GOAL**

SAP offers an enormous array of manufacturing applications. These applications span all industries, work across different types of manufacturing methods, and seamlessly link manufacturing operations to other business functions by leveraging a best-in-class technology platform. Such enormous technical capability makes SAP the leading provider of manufacturing solutions today, and the one company with the industry experience and the vision to make adaptive manufacturing a reality.

# APPENDIX A

## DETAILS OF SAP® MANUFACTURING SOLUTION CAPABILITIES

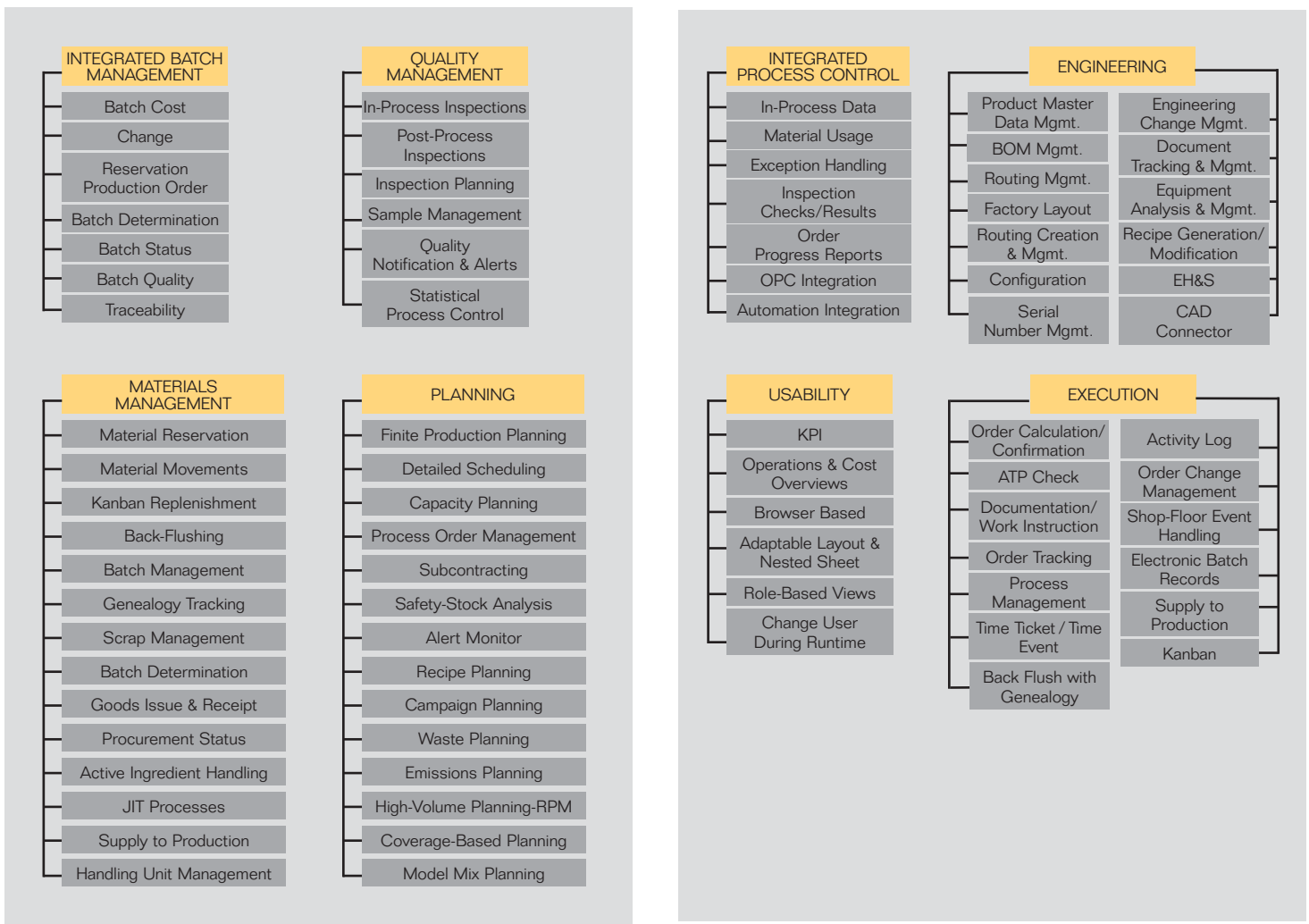


Figure 8: SAP Manufacturing Solution



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